



Acquisition Directorate

Research & Development Center

Report No. CG-D-05-18

Joint Maritime Test Facility (JMTF) Summary Burn Report for FY17

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September 2017



Homeland Security

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JMTF Summary Burn Report for FY17

Technical Report Documentation Page

1. Report No. CG-D-05-18		2. Government Accession Number		3. Recipient's Catalog No.	
4. Title and Subtitle Joint Maritime Test Facility (JMTF) Summary Burn Report for FY17				5. Report Date September 2017	
				6. Performing Organization Code Project No. 4704	
7. Author(s) K. Hansen				8. Performing Report No. R&DC UDI # 1500	
9. Performing Organization Name and Address U.S. Coast Guard Research and Development Center 1 Chelsea Street New London, CT 06320				10. Work Unit No. (TRAIS)	
				11. Contract or Grant No.	
12. Sponsoring Organization Name and Address COMMANDANT (CG-MER) US COAST GUARD STOP 7516 2703 MARTIN LUTHER KING JR AVE SE WASHINGTON, DC 20593				13. Type of Report & Period Covered Final	
				14. Sponsoring Agency Code Commandant (CG-MER) US Coast Guard Stop 7516 Washington, DC 20593	
15. Supplementary Notes The R&D Center's technical point of contact is Kurt Hansen , 860-271-2865, email: Kurt.A.Hansen@uscg.mil					
16. Abstract (MAXIMUM 200 WORDS) The Coast Guard Research and Development Center (RDC) has been conducting fire research at the Joint Maritime Test Facility (JMTF) since 1972. Most of the testing has occurred on board vessels that were moored next to Little Sand Island in Mobile Bay in Alabama. Starting in 1990, testing for the use of in-situ burning (ISB) as a response tool for oil spills was initiated using a shallow 50-foot by 50-foot pan. A larger pan (100 feet by 30 feet) was built in 1998 and used for the development of a testing guide for fire-resistant boom. This resulted in ASTM F2152 Standard Guide for In-Situ Burning of Spilled Oil: Fire Resistant Boom. Testing was completed in 2000 and the facility closed. In 2005, the storm surge from Hurricane Katrina heavily damaged the facility. After the successful use of ISB during the Deepwater Horizon Response, some recommendations for the development of improved ISB equipment were identified but no progress made. In 2015, RDC started the refurbishment of the facility and three tests have been performed in partnership with the Bureau of Safety and Environmental Enforcement (BSEE). In 2017, CG RDC installed a wave maker that provides the minimum requirements for an ASTM F1252 test. This is the only known facility in the world that can perform this test.					
The CG Research and Development Center In-situ burn, ISB, test facility, spill response			18. Distribution Statement Distribution Statement A: Approved for public release; distribution is unlimited.		
19. Security Class (This Report) UNCLAS//Public		20. Security Class (This Page) UNCLAS//Public		21. No of Pages 26	22. Price



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EXECUTIVE SUMMARY

The USCG Research and Development Center (RDC) has operated the Joint Maritime Test Facility (JMTF) on and adjacent to Little Sand Island in Mobile Bay since 1972. Most work has focused on shipboard fires using vessels moored at the site. In 1990, one pan was built to investigate the use of in-situ burning (ISB) as a response tool for oil spill response. RDC performed research on the science of the burns, including detailed analysis of the plumes and residue. Then in 1998, another pan was built to develop a testing procedure to evaluate the performance of fire-resistant boom. The result was ASTM F1252, Standard Guide for In-Situ Burning of Spilled Oil: Fire-Resistant Boom. In 2005, most of the infrastructure, including the burn pan, was damaged by the storm surge of hurricane Katrina.

After the successful use of ISB during the response to the Deepwater Horizon oil spill, recommendations were identified to improve the equipment and the processes of ISB. RDC, in partnership with the Bureau of Safety and Environmental Enforcement (BSEE), started re-leveling the second pan and developing the required infrastructure in 2015, and three test series have since been conducted. The first test in 2015 was used as an initial assessment of the rebuilt system, while the later tests were conducted for ISB research, discussed below.

In FY2017, BSEE provided funding for tests to be performed by the Pacific Northwest National Laboratories (PNNL) and Worcester Polytechnic Institute (WPI). PNNL evaluated the use of a sawdust aggregate to enhance ISB using very small amounts of material and less than 2 gallons of crude oil. WPI evaluated a combination mesh and metal coil system also to enhance the burn efficiency. Both were considered large-scale tests based on testing done at their respective laboratories. RDC also funded the fabrication of a new wave maker system that utilized the existing paddle with a new hydraulic cylinder, hydraulic power unit, and a wave-dissipation beach at the far end of the tank.

RDC is now investigating future use of the facility for ISB research and other alternatives.



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LIST OF ACRONYMS, ABBREVIATIONS, AND SYMBOLS

ASTM	American Society of Testing and Materials
BP	British Petroleum
DAQ	Data Acquisition System
GST	Gulf Strike Team
ISB	In-Situ Burning
ICS	Incident Command Structure
JMTF	Joint Maritime Test Facility
kW	kilowatts
kW/m ²	kilowatts per square meter
LSI	Little Sand Island
m	meter
m ²	square meters
mph	miles per hour
NOAA	National Oceanic and Atmospheric Administration
PNNL	Pacific Northwest National Laboratory
psi	pounds per square inch
RDC	US Coast Guard Research and Development Center
SDS	Safety Data Sheets
NIST	National Institute of Standards Testing
NRL	Naval Research Laboratory
PM	Project Manager
PPE	Personal Protection Equipment
TC	Thermocouple
USCG	United States Coast Guard
USN	United States Navy
WPI	Worcester Polytechnic Institute



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1 BACKGROUND

In 1972, the US Coast Guard Research and Development Center (RDC) established the Joint Maritime Test Facility (JMTF) at Coast Guard Sector Mobile in Mobile, Alabama, as the Fire and Safety Test Detachment (FSTD). Used as test platforms, multiple retired commercial vessels were moored at the island, through the years, ending with the *State of Maine*, which was removed in 2010. Tests conducted on these vessels included evaluation of vessel construction, shipping container construction, and the use of water for fire sprinkler systems. In parallel, the Naval Research Laboratory (NRL) moored the ex-USS Shadwell at the island to perform fire research for combat ships. In 1990, RDC built a 15 meter by 15 meter (50-foot by 50-foot) shallow burn pan collaborating with the National Institute of Standards and Testing (NIST) and several other federal and international organizations to research in-situ burning (ISB) of oil spills. While research had been occurring since the 1970s, the building of the pan started a comprehensive science program. The pan was used to conduct tests to collect data about burn science, including emissions (soot and smoke) and the properties of remaining residue for crude oil and diesel. This pan was later dismantled.

The next facility improvement phase was the building of a larger pan (100 feet by 30 feet test section) mounted with a wave paddle in 1998. This was used to develop a standard test to evaluate fire-resistant boom and was used for three years and tested nine potential boom designs. The American Society of Testing and Materials (ASTM), Standard Guide for In-Situ Burning of Spilled Oil: Fire-Resistant Boom was developed (ASTM 1252). This standard appeared to work well as the boom designs that tested well in the ASTM evaluation also worked well during the Deepwater Horizon (DWH) Response, including burns lasting over 11 hours. The pan had not been used since 2002 when it was lifted from the sand and moved by Hurricane Katrina in 2005. The storm also heavily damaged the supporting infrastructure.

After the Deepwater Horizon Response, work groups were formed by the American Petroleum Institute (API) composed of industry, federal, and state partners. These groups developed a number of documents that included operations manuals, personnel qualifications, and guidance to industrial hygienists and safety personnel. However, the RDC and the Bureau of Safety and Environmental Enforcement (BSEE) recognized that the equipment recommendations coming out of DWH had not been addressed (Merrick, et.al. 2015). These included using ISB in harsher environments (higher waves and wind), developing alternative igniters and better burn efficiency in order to reduce the smoke plume and the amount of burn residue. In 2015, RDC repaired the burn pan, installed fuel delivery and monitoring systems, and conducted an initial test burn to verify system operations and test procedures (Back, et.al. 2015). A method to implement the standard ASTM test was developed (Back, et.al. 2016) and was used as a basis for developing follow-on test procedures. RDC expects to continue future tests with references to other ASTM standards that address operational issues and ignition devices (ASTM 2013, 2014).

2 LITTLE SAND ISLAND (LSI) FACILITY

The burn pan was fabricated out of steel on Little Sand Island (LSI) in 1998. The outer burn pan is approximately 33.0 meters (108 feet) long, 11.6 m (38 ft) wide and 1.5 m (5 ft) deep. The inner test area is 100 feet by 30 feet. The 1.02 m (4 ft) wide trough separates the inner burn wall from the outer wall, and is designed to be filled with water to act as a protective heat-sink. The top of the trough is covered with deck grating and serves as a walkway around the top of the burn pan. A safety railing was added in 2016. About



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4.9 m (16 ft) of the north end of the burn pan is occupied by the wave generator that features a hydraulic cylinder connected to a wave paddle suspended 4.9 m (16 feet) above the tank floor.

The status of the burn facility on Little Sand Island at the beginning of Fiscal Year 2017 (FY17) was one of transition. In FY17, two series of test burns were conducted to support BSEE-sponsored research to begin addressing the outstanding efficiency issues. Most of the lessons learned from the FY16 initial assessment tests (Back, et.al, 2016) were implemented, including major relocation of storage containers and oil tanks. Since the 2016 test and resulting report focused on the ASTM standard, most of the follow-on facility improvements were needed to ensure safety and flexibility for the facility to handle academic and other researchers. This also included improvement in some of the processes, identification of personal protection equipment (PPE), safety officer and observer procedures, and refining acceptable ignition methods.



Figure 1. View of Little Sand Island in October 2016.

3 PACIFIC NORTHWEST NATIONAL LABORATORY (PNNL) TESTING

3.1 PNNL Test

The objective of the researchers at the Department of Energy's [Pacific Northwest National Laboratory](#) (PNNL) was to conduct a study entitled “Multifunctional Herding-Sorbent Agents for Use in Icy Water” under contract to BSEE. They aimed to combine herding agents with “aggregator” materials that could gather and keep the oil spill relatively intact until it could be recovered or burned. A second objective was to determine if the material could support microorganisms that can naturally degrade oil. After some initial work, sawdust was identified as a good aggregator and pre-treatment options were evaluated to make it exceptionally oil-attracting and buoyant. The nontoxic material absorbed up to five times its weight in oil and stayed afloat for at least four months in meso-scale tests.

RDC developed a test and safety plan for PNNL based on the Incident Command System (ICS) format that was successful during the initial test burn in 2015. A sample of the testing check sheet for these tests is shown in Appendix A. A similar sheet was created for each test sequence. The fire-resistant boom was configured in a 7-foot by 7-foot square alongside the west side of the burn pan. Temperature gauges were installed on the four sides of the square on the inside with two additional thermometers outside on the north



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and south sides. Two heat-flux gauges were mounted on the east and west side of the boomed area. Video cameras were mounted on poles attached on the outside wall of the burn pan trough. The tests consisted of placing crude oil within the boomed area, distributing the aggregator, waiting for about 10 minutes and then igniting the combined oil/aggregator. A small propane burn igniter was used to start the burn. A total of seven burns were conducted with burn times of only 2-3 minutes (Figure 2). Some smoke that was blown towards the west and north dispersed before reaching the water. In some of the tests, leftover aggregator was left unburned on top of the oil (Figure 3). It was not clear how successful the burn was and the aggregator appeared to suppress some of the burning. A sample of the data collection using the NRL Data Acquisition System (DAQ) shows the temperatures and heat flux measured for the baseline study that included oil without any aggregator (Figure 4). PNNL took samples of the leftover residue to assess burn efficiency. The project report has not been completed but will eventually be loaded on the BSEE Internet site at: <https://www.bsee.gov/research-record/osrr-1071-multifunctional-herding-sorbent-agents-use-icy-water>



Figure 2. Aggregate and oil burning.



Figure 3. View of test area after burn.



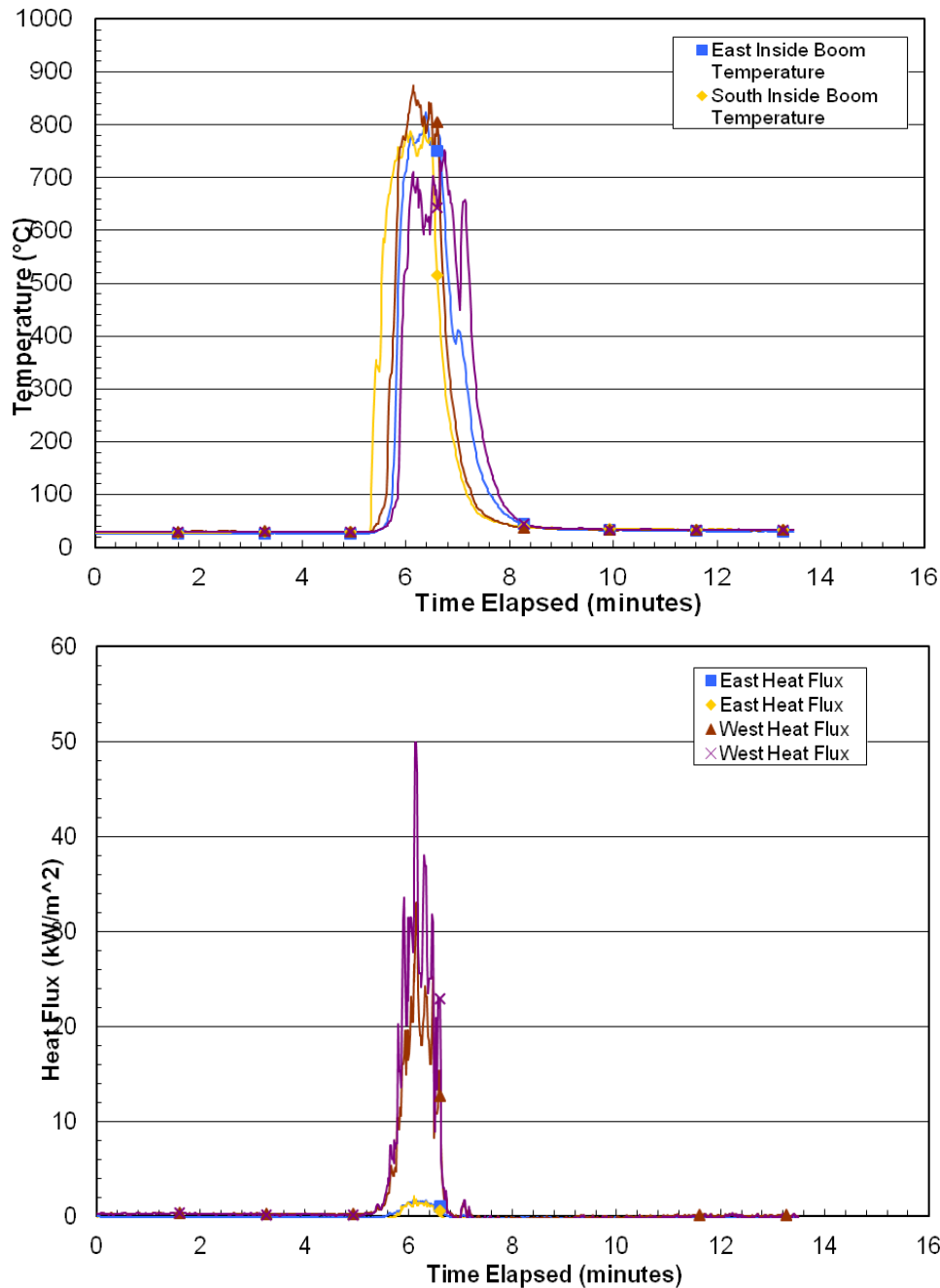


Figure 4. Examples of temperatures (top) and heat flux (bottom) for baseline test.

3.2 Lessons Learned from PNNL Tests

A compilation of lessons learned includes:

- Improvements are needed for all plans, including testing and safety. Standard operating procedures are documented in some areas but not all are complete. Draft plans need to be completed further in advance (2-4 weeks) so that final arrangements can be made as needed. More details for specific personnel PPE, based on assigned tasks, are needed.



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- Communications appeared to work well with the test director on one channel and safety observers on another.
- Safety and test briefs should follow a standard presentation format for each test.
- RDC needs to set expectations and coordinate closer with customers to ensure all equipment is on-site before any testing begins. This includes understanding what equipment is being shipped in and will be returned, exact travel plans, coordinate with visitors to avoid interfering with testing, confirm PPE requirements in advance, and confirm data gathering requirements.
- Better procedures for site clean-up, equipment decontamination, and waste disposal are needed. Waste amounts expected to be generated should be determined beforehand and specific disposal containers/ bags and procedures need to be better defined in advance.
- A better method to secure the rolling catwalk over the tank is needed to ensure stability.
- Short burns of 2-5 minutes may be performed even when the wind is coming from outside of the normal wind envelope, unless the plume is blown directly into the control shack. It appears that the plume dissipates before reaching the edge of the island and will not approach the no-smoke zones over downtown Mobile or the causeway.

4 WORCESTER POLYTECHNIC INSTITUTE (WPI) TESTING

4.1 WPI Tests

The objective of this proof-of-concept study was to develop the concept and design of a simple prototype system to directly burn off oil slicks in booms at high efficiencies and with low emissions. The approach used noncombustible and conductive immersed objects to enhance the heat transfer from flames back to the fuel to achieve higher vaporization rates. The proof-of-concept project was carried out at WPI in three phases, starting with small-scale (10 and 25 cm diameter burn pans) and moving to intermediate scale (70 cm diameter burn pan). The variables include basic material and geometric parameters that affect the heat transfer and mass loss rates, effects of thickness, surface area and void volume of the metal mesh/wool blanket as well as the diameter, pitch, and material of the springs. The resulting main components selected were a copper mesh blanket and copper springs than could be located at any position and at different heights. The test at the JMTF was the third large-scale (140 cm diameter outdoor burn pan) phase used to evaluate a prototype burner for field use. The project report has not been completed but will eventually be loaded on the BSEE Internet site at: <https://www.bsee.gov/research-record/osrr-1068-offshore-oil-burn-enhanced-floating-immersed-objects>

RDC worked closely with BSEE and WPI to develop a test plan. Numerous teleconferences and meetings were held leading up to the development of the final test plan that resulted in reducing the amount of time needed at the JMTF from 3-4 weeks to 2 weeks. RDC representatives emphasized establishing priorities to develop a test plan that would minimize and optimize the use of the time at the facility. The discussions also emphasized that the design of the system needed to be easily and quickly assembled on the site. About 1 month before the tests, several RDC representatives visited WPI to witness the assembly process and help WPI review the design. The result shown in Figure 5a, used a burner ring to confine the oil and support the blanket and thermocouple (TC) towers. The final configuration with the blanket and copper springs in place



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can be seen in Figure 5b. RDC placed a fire-resistant boom around the ring to keep any burning oil from spreading out and potentially damaging sensor wiring or other data gathering components (Figure 6). Besides collecting temperature, heat flux and other data, WPI also captured smoke from the plume to analyze. The Outdoor Gas Emission Sampling System (OGES) was used to sample and analyze the gas concentrations of O_2 , CO_2 , and CO (see Figure 7) and can also be seen on the left side of Figure 6.

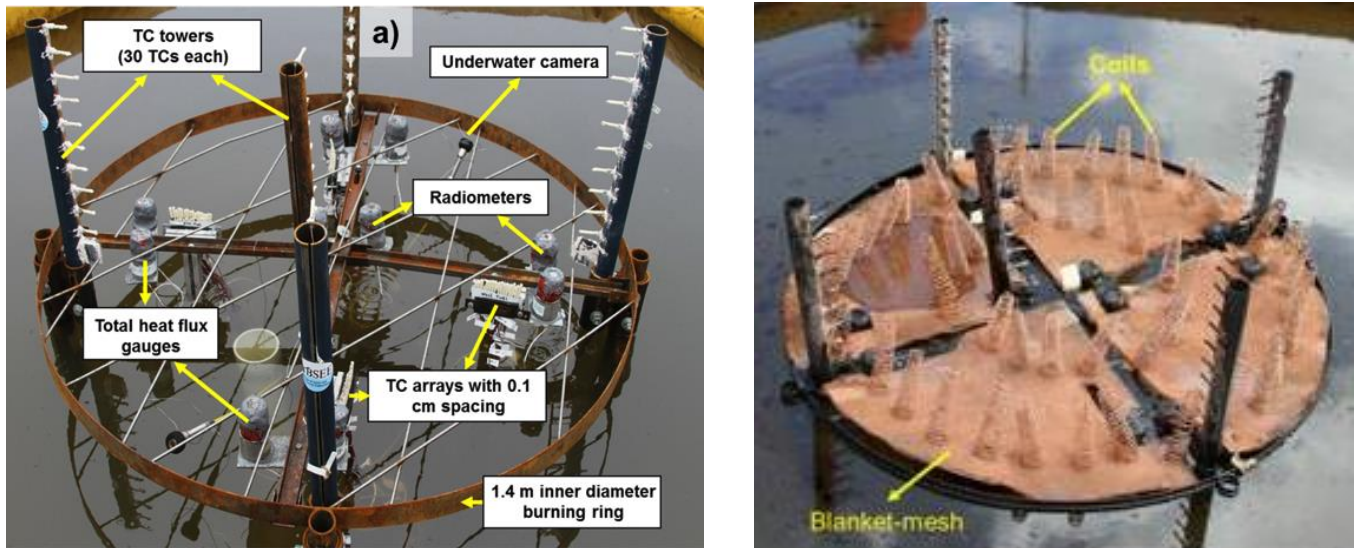


Figure 5. Views of test apparatus before filling burn pan with water (left) and test configuration with mesh and coils in place (right).



Figure 6. Overhead view of a burn with fire-resistant boom in place.



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Figure 7. Outdoor Gas Emission Sampling System (OGES) in place.

Five tests were done with the general results showing in Table 1. The baseline burn was without any blanket or coils, then for subsequent tests the mesh and coils were added. Figure 8 clearly shows that the color of the smoke plume is much lighter for the blanket with 48 coils case (VH). The light color smoke indicates reduction in small black particles of carbon and more complete combustion. In general, the use of the mesh and coils appears to increase the efficiency of the burn.

Table 1. Experimental matrix and results.

Test	Test Duration (min)		Wind		Mass Loss Rate (mm/min)	CO/CO ₂	Residue Removal Efficiency
	wfs*	wofs**	Speed (m/h)	Direction (From – To)			
Baseline	15	4	8.12	W-E	2.98	0.055	67.8
Blanket	20	39	7.65	N-S	5.61	0.040	96.2
Blanket + 32coils	14	37***	3.94	NW-SE	8.36	-	97.1
Blanket + 48 coils (VH)	20	62	11.96	N-S	12.84	0.027	98.5
Blanket + 48 coils (SH)	12	59	9.14	NW-SE	17.36	-	98.2

*wfs: with fuel supply, **wofs: without fuel supply, ***extinguished by the fire team, VH: Various heights, SH: Same height.





Figure 8. Picture of the smoke plume a) baseline, b) blanket with 48 coils (VH).

4.2 Lessons Learned from WPI Tests

Many of the issues involving consistency across the procedures and process from the PNNL tests were partially answered prior to this WPI test. Other outstanding issues include:

- Further identification for training required for each test support position.
- A more careful review and segregation of assigned tasks, as the Safety Officer was also the RDC Public Affairs Officer.
- A better observation area is needed. The researchers and the press were not allowed on the grating area during any of the burn testing, and details of the fire could not be adequately observed from ground level.
- A more responsive ability to change burn pan water depth is needed. This will allow personnel better and safer access to test apparatus in the event a repair or adjustment is required, and for safer and more efficient removal of test apparatus at the completion of a test series.

5 WAVE MAKER AND BEACH INSTALLATION

In 2016, RDC awarded a contract to Chant Engineering to design, build, and install a system that would use the existing wave paddle to create the wave required by standard ASTM F2152. A wave-dissipation beach, a new hydraulic cylinder and a hydraulic power unit were installed beginning in May (Figures 9 through 12). The system was installed and tested, but the resulting waves damaged the beach where sections of the corrugated steel pulled through or broke off the mounting studs that were welded to the frame. The repairs were completed in July, and a final user manual and the system were accepted in August. The system is able to make wave heights up to 12 inches with a 2-second period, which exceeds the required ASTM standard.



Figure 9. View of energy dissipation beach with (left) and without water (right).



Figure 10. Wave height measurement device.



Figure 11. Close up of hydraulic cylinder.



Figure 12. View of Hydraulic Power Unit (HPU).

While the system was operated with power from the diesel generator on LSI, the size of the waves and operation was limited by this generator's capacity. Any attempt to exceed these current parameters either by increasing the wave height or shortening the period will cause the generator to trip the circuit breaker. In addition, the tests performed for the minimum requirements were accomplished with the beach in the full-up position. Additional calibration tests are needed to see how the wave conditions change with different beach slopes and when the beach is submerged. This last condition usually will create a more confused surface causing waves to break within the tank, a condition needed for more sophisticated burning or dispersant tests.



6 SUMMARY AND FUTURE PLANS

Since the burn pan was refurbished in 2015, RDC has conducted three safe and successful burns. On the main test days, LSI hosted up to 24 people; while a maximum of 36 people were hosted during a WPI media day, including local and national media. Burns have lasted 2-62 minutes with no smoke entering the designated no-smoke zones near the city of Mobile or the coal loading dock.

RDC continues to improve the facility on LSI, including the procurement of a new telehandler and 4-wheel drive vehicle. CG RDC has identified and is undertaking additional improvements to make the facility more useful and safer for researchers to observe test burns and collect data. The JMTF staff continues to clean up some of the remaining debris left on the island due to the past hurricane damage.

Earlier in the year, NRL notified RDC that it would be dismantling the ex-USS Shadwell and discontinuing operations at the JMTF. As of September, the exact date of the departure is not known, but is expected to be around the end of calendar year 2017. Future plans for the wave maker and burn pan were linked to the support provided by NRL for transportation, electrical power, and water. RDC will be evaluating alternatives to the support that NRL provided, such as boat and boat operators, pumps, stable electricity, and data acquisition among others.



7 REFERENCES

ASTM F1788-14 Standard Guide for In-Situ Burning of Oil Spills on Water: Environmental and Operational Considerations.

ASTM F1990-13 Standard Guide for In-Situ Burning of Spilled Oil: Ignition Devices.

ASTM F2152 Standard Guide for In-Situ Burning of Spilled Oil: Fire Resistant Boom.

Back, G.G., R. A. Grantham, J.P., Farley, H. Pham, and T. Polyard, "In Situ Burn (ISB) Procedure Development and Demonstration: Validation Test Report," NRL Ltr Rpt Ser 6180/0258A:JPF, Naval Research Laboratory, Washington, DC, 56 pages, 2015.

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APPENDIX A. PRELIMINARY PNNL TEST CHECKLIST

PNNL Test # _____ Test Description: _____
Date: _____ Time: _____

Environmental Data

- _____ Water Temperature
- _____ Air Temperature
- _____ Wind Velocity
- _____ Salinity
- ___ Water Sample Taken
- YES or NO Aggregator Applied
- _____ Oil Amount

Safety Brief ___

Pre-Test Checklist

1. ___ Systems ON/Running
2. ___ Sync Times
 - ___ Computer
 - ___ DVR
 - ___ GoPros
3. ___ DAQ Check
4. ___ DVR Check
5. ___ GoPro Check
6. ___ 1 ½ inch Hand line Charged
7. ___ Fire Ext. in Place
8. ___ Calls Made
 - ___ Brookley Field
 - ___ Fire Dept.
 - ___ McDuffy Coal Terminal
 - ___ Harbor Master

Test Checklist

1. ___ Clear all Debris
2. ___ Collect Environmental Data
3. ___ Setup PNNL GoPro Underwater
4. ___ Start NRL GoPros
5. ___ Pour Crude Oil
 - Disperse on surface w/ rolling pan
 - Let spread in burn pan (approx. 5 min)
6. ___ Move Catwalk Away
7. ___ Apply Aggregator w/ Blower and Hopper Combo



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- Let aggregator soak up crude oil (approx. 10-30 min)
- 8. Pre-Ignition Check/Announcement
- 9. Ignite Fuel
- 10. All Back Out
- 11. All Clear Call
- 12. Move Catwalk Back
- 13. Collect Samples
 - Water
 - Debris
 - All Residue Left
- 14. Retrieve PNNL GoPro
- 15. Hotwash

Times to Note:

Time Note

Fuel Poured

Aggregator Applied

Call for Ignition

Fuel/Aggregator Ignited

50% Surface Area is Burning before Fire Peak

50% Surface Area is Burning after Fire Peak

Fire Self-Extinguishes

All Clear Call



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